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Performance of Ultraviolet Gratings as Affected by Simulated Space Environment

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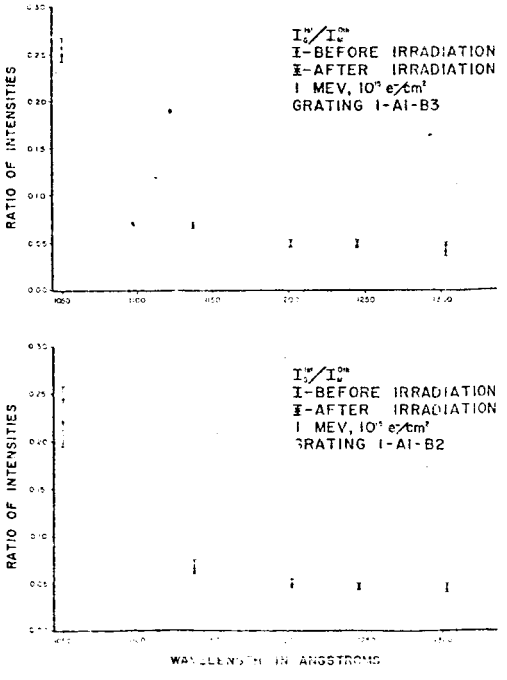
A study is in progress in our laboratory to determine any possible deterioration in the performance characteristics of gratings blazed for the uv region of the spectrum due to electon bombardment. Gold replica plane gratings, 1280 lines/mm and blazed at 700 Å, were subjected to a total electron dose corresponding to the maximum dose that might be received by an orbiting satellite in a one year period[1] in order to determine any possible optical degradation.

The procedure adopted to determine any such changes was to test the performance of the gratings in our laboratory, to irradiate them with a 1-MeV electron beam at a total dose of 10^{15} electron cm^{-2} and then to repeat the initial laboratory tests. The efficiency of the grating was measured as a function of wavelength. This was accomplished by measuring the reflective intensity of the incident monochromatic radiation in the first and zero order of the grating and the ratio (I_1/I_0) determined. The grating's zero order intensity and the reflective intensity from a MgF_2 reference mirror, which was positioned in place of the grating, was measured, and the ratio (I_0/I_m) obtained. The relative efficiency of the grating in first order was determined by multiplying these two ratios:

$$E(\lambda) = (I_1/I_0) \cdot (I_0/I_m) = (I_1/I_m)$$

This procedure was repeated with six spectral lines, from 1048 Å to 1302 Å.

The experimental configuration used for testing the gratings before and after irradiation can be considered in two parts: the uv monochromatic source and the test chamber. These two chambers, which have individual pumping and control systems, are separated by a manually operated gate valve. The uv source consisted of a Hinteregger discharge lamp operated with a mixture of 0.5 Torr of Ar and 0.2 Torr of He. This lamp was excited by an ac power supply operated at 1500 V and a current of 60 mA. Dispersion of the uv radiation was accomplished with a 1-m monochromator (McPherson model 225). The test chamber consisted of a 0.3-m monochromator (McPherson model 218), with its entrance slit mounted at the position of the exit slit of the 1-m instrument. A detecting system consisting of a sodium salicylate scintillator and an EMI 9514 photomultiplier was mounted at the exit slit of the 0.3-m monochromator.



First order relative efficiency of the exposed grating A1-B3 and the covered companion grating 1-A1-B2.

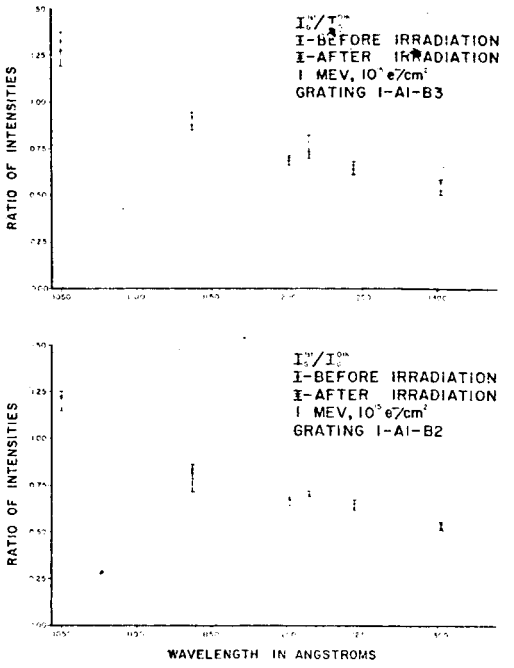


Fig. 2. First order to zero order intensity ratios of the exposed grating 1-A1-B3 and the covered companion grating 1-A1-B2.

Irradiation of the gratings was performed using a 1-MeV Dynamitron at NASA Langley Research Center. This facility was equipped with a water-cooled sample holder located in an evacuable chamber. Two gratings were irradiated simultaneously, one of which (companion grating) was shielded from the electron beam by a 0.25-cm aluminum plate. Thus, both the irradiated and companion gratings were subjected to the same vacuum system environment during irradiation. The gratings were bombarded at the rate of 10^{11} electrons cm^{-2} sec^{-1} at an energy of 1 MeV to obtain a total dose of 10^{15} electrons cm^{-2}. During irradiation the pressure in the test chamber was maintained at 5×10^{-5} Torr and the temperature of the irradiated gratings did not rise more than 5°C above room temperature. These gratings showed no evidence of contamination.

Figure 1 shows the data for the relative efficiency (I_1/I_m) of the irradiated grating both before and after irradiation and also the corresponding data for the companion grating which was shielded by the 0.25-cm aluminum plate. Figure 2 shows the corresponding data for the first order to zero order intensity ratios (I_1/I_0).

These data show that neither the exposed nor companion grating has undergone any significant change in either first order efficiency or reflectivity from exposure to the simulated space environment.

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Reference

1. Fred W. Paul (Goddard SFC), Joint Meeting of Technical Groups, Optical Society of America, Detroit, Mich., October 1967.